DOCUMENT RESUME

ED 383 772 TM 023 834

TITLE	Math Assessment Alternatives.
INSTITUTION	Northwest Regional Educational Lab., Portland, OR. Test Center.
SPONS AGENCY	Department of Education, Washington, DC.
PUB DATE	30 Jun 92
NOTE	21p.
PUB TYPE	Reference Materials - Bibliographies (131)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Curriculum Development; *Educational Assessment; Elementary Secondary Education; Mathematics Instruction; *Mathematics Tests; Problem Solving; State Programs; *Student Evaluation; *Test Construction; *Testing; Testing Programs
IDENTIFIERS	*Alternative Assessment; *Performance Based Evaluation

ABSTRACT

The articles in this annotated bibliography represent holdings of the Test Center in the area of assessment alternatives in mathematics. Presence on the list does not imply endorsement of the practices by the Test Center; rather, articles are made available to stimulate thinking and provide ideas. Some entries present informal assessments intended for classroom use. The list includes 56 documents related to elementary and secondary mathematics and a variety of alternative approaches to assessment. (SLD)

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TAC-B-443

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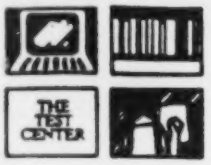

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MATH ASSESSMENT ALTERNATIVES
June 30, 1992

The following articles represent Test Center holdings to date in the area of assessment alternatives in mathematics. Presence on the list does not necessarily imply endorsement. Articles are included to stimulate thinking and provide ideas. Some of the entries are informal assessments, and are intended mainly for the classroom. For more information contact Judy Arter or Ann Davis at 503-275-9500, Northwest Regional Educational Laboratory, 101 S.W. Main, Suite 500, Portland, Oregon 97204.

Algina, James, and Sue Legg (Eds.). ***Special Issue: The National Assessment of Educational Progress.*** **Located in: Journal of Educational Measurement, 29, 1992.**

This special issue of JEM discusses the National Assessment of Educational Progress (NAEP)--history, specification of content and design of assessments for 1992 and beyond (math, reading, writing), how students are sampled, and how results are reported. Although some articles are somewhat technical, the general pieces on NAEP's history, and the design of current assessments will be interesting to the general readership.

The current plans for math include:

1. Use of calculators for about 70 percent of the test.
2. Estimation skills tasks using an audiotape.
3. Yes/No questions to determine the extent to which students understand the same information when it is presented in different forms.
4. Constructed response questions in which students are asked to document their solutions by drawing their answers, writing explanations, or providing their computations.

Scoring guides for open-ended questions are tailored to each question. Some examples are provided.

(TC#150.6JEM292)

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Bock, R.D. *The "Content X Process" Classification of Mathematics Items: Conjoint Scoring*, 1987. Available from: University of Chicago, 5801 S. Ellis Ave. Chicago, IL 60637, 312-702-1234.

In this paper, the author describes the content specifications for a grade 8 test in mathematics used in a study at UCLA. A "content x process" matrix was used to specify test content. Content included numbers, algebra, geometry, measurement, and probability/statistics. Each of these was crossed with procedural skills (calculating, rewriting, constructing, estimating, executing algorithms), knowledge of facts and concepts (terms, definitions, concepts, principles), and higher-level thinking (proof, reasoning, problem solving, real-world applications). Items that represent some of the cells in the matrix are provided as examples. All items are multiple-choice.

(TC#500.5CONXPR)

California State Department of Education. *A Question of Thinking*, 1989. Available from: California State Department of Education, P.O. Box 944272, Sacramento, CA 94244-2720, 916-445-1260.

This report describes the results of 12th grade student assessment using open-ended math problems that was part of the California Assessment Program (CAP). The open-ended problems were scored using rubrics developed for each problem. These rubrics are described, and "anchor" papers for the six scale values for each rubric are provided. Although there is a separate rubric for each problem, they are all intended to reflect the following dimensions of problem solving: understanding of mathematics, use of mathematical knowledge, and ability to communicate about mathematics.

(TC#500.3AQUESO)

Campbell, D. *Arizona Student Assessment Plan*, 1990. Available from: Arizona Department of Education, 2102 W. Indian School Rd., Phoenix, AZ 95015, 602-264-1774.

The Arizona Assessment Program has several parts: a short standardized achievement test, non-test indicators, and performance assessments in reading, math and writing. The performance tests are designed to measure the state's Essential Skills. The math portion presents an extended problem solving situation that requires short answers, extended answers, and explanations of answers. Each extended exercise has its own specific set of scoring procedures that involve assigning a point value if various things are present in the response.

(TC#060.3ARISTA)

Center for Innovation in Education. *Math Their Way*, 1990. Available from: Center for Innovation in Education, 20665 4th Street, Saratoga, CA 95070.

Math Their Way is an instructional program designed for grades K-2 that emphasizes manipulatives. Chapter 3 deals with assessment; the suggested assessment activities tie into the instructional program. These are suggested "formal assessments" to be used to track student progress two to four times a year. They are really not intended for daily use. There are 18 assessments to evaluate three areas--prenumber concepts and skills,

number operations, and place value. All assessments are individual and performance based. No technical information is provided.

(TC#070.3MATTHW)

Champagne, Audrey B. *Cognitive Research on Thinking in Academic Science and Mathematics: Implications for Practice and Policy.* Located in: Diane Halpern (Ed.) Enhancing Thinking Skills in the Sciences and Mathematics, 1992. Available from: Lawrence Erlbaum Associates, Publisher, 365 Broadway, Hillsdale, NJ 07642.

Although this article is not strictly about assessment, it discusses some topics of relevance to assessment. Specifically, it has a very nice section on the relationship between the tasks given to students and what they can learn. For example, students can't learn as efficiently to integrate knowledge if they are never given tasks that require them to do this. This also has relevance to designing "authentic" tasks for performance assessments.

(TC#000.6COGRET)

Charles, R. *Evaluating Progress in Problem Solving*, 1989. Located in: Communicator, 14, 2, pp. 4-6. Also available from: The California Mathematics Council, 1414 S. Wallis, Santa Maria, CA 93454, 805-925-0774.

This article presents a rationale for analyzing student open-ended problem solving in a systematic fashion. One sample analytical scoring rubric is presented. The traits are: understanding the problem, planning a solution, and getting the answer. The author also proposes some other questions to ask as one looks at student problem solving: Did the student seem to understand the problem? Were the approaches used to solve the problem feasible for finding a solution? Does the answer make sense in terms of the question to be answered?

(TC#500.3EVAPRI)

Clark, David. *The Mathematics Curriculum and Teaching Program*, 1988. Available from: Curriculum Development Centre, Canberra, Australia. Also available from: ERIC ED 287 722.

This document was developed to assist classroom teachers to improve their day-to-day assessment of mathematics. Content includes: rationale for assessment alternatives in mathematics, instructions for a two-day inservice program using the materials, instructions on how classroom teachers can use the materials without training, and a series of exercises, formats and ideas for classroom assessment.

Assessment ideas include: help with systematically recording information from informal observations using checklists and "folios" of student work; setting up opportunities for assessment by giving students good tasks to do; assessing problem solving; student self-reflection; and communicating results.

This is written in a very user-friendly manner and contains some good ideas, especially in the areas of designing tasks, problem solving and self-reflection. We found some of the descriptions of activities a little too sketchy.

(TC#500.3MCTPMA)

Collis, Kevin and Thomas Romberg. ***Assessment of Mathematical Performance: An Analysis of Open-ended Test Items*, 1989. Available from: National Center for Research in Mathematical Sciences Education, Wisconsin Center for Education Research, University of Wisconsin, School of Education, 1025 W. Johnson St., Madison, WI 53706, 608-263-4200.**

This paper discusses the implications of research on cognitive development in math for designing assessments. This discussion leads up to some general considerations for assessment design and a general summary of current assessment trends. Some sample test items are provided to illustrate some of the points. Also some sample performance assessment-type items are shown, but they are not critiqued in light of the previous discussion.

(TC#500.6ASSMAP)

Collis, Kevin and Thomas Romberg. ***Collis-Romberg Mathematical Problem Solving Profiles*, 1992. Available from: Australian Council for Educational Research Limited, Radford House, Frederick Street, Hawthorn, Victoria 3122, Australia. Also available from: ASHE, P. O. Box 31576, Richmond, VA 23294.**

This assessment devise has 20 open-ended problems to solve--one problem in each of five areas (algebra, chance, measurement, number, and space) with four questions per problem area. Each question is designed to tap a developmental level of formal reasoning. For example, the "A" question determines whether the student can use one obvious piece of information from the item, while the "D" question determines whether the student can use an abstract general principle or hypothesis derived from the information in the problem.

Responses to each question are scored right/wrong. The number of correct responses in each subject and developmental level determine what to do instructionally. Suggestions are given for instructional strategies for the various developmental levels. No technical information is provided.

(TC#500.3COLROM)

Commission on Standards for School Mathematics. ***Curriculum and Evaluation Standards for School Mathematics*, 1989. Available from: National Council of Teachers of Mathematics, 1906 Association Drive, Reston, VA 22091.**

This book contains standards for curriculum and assessment that attempt to create a coherent vision of what it means to be mathematically literate. This book has been quoted extensively and appears to be the current "standard" for what should be in a math curriculum.

The assessment section covers: three statements of philosophy concerning assessment (alignment, multiple sources of information, and appropriate assessment methods and uses); seven sections on assessing various student outcomes (e.g., problem solving, communication, reasoning, concepts, procedures, and dispositions); and four sections on program evaluation (indicators, resources, instruction, and evaluation team). Each of the seven sections on assessing student outcomes briefly describes what the assessment should cover and provides some sample assessment tasks and procedures.

(TC#500.5CURANE)

Dalton, Michael. *Oregon Dimensions of Problem Solving*, 1990. Available from: Oregon Department of Education, 700 Pringle Parkway S.E., Salem, OR 97310, 503-378-4974.

The Oregon State Department of Education is currently sponsoring a consortium effort to develop an analytical trait scoring system for open-ended math problems. Two versions of the rubric are included; the second version is a modification of the first, based on a pilot test. The team is currently trying out the second version on problems across multiple grades. The traits are:

1. Conceptual understanding of the problem
2. Procedural knowledge
3. Problem solving skills and strategies
4. Communication

The current version includes a scoring guide for each trait. The ultimate goal is to develop a package that also includes anchor performances, although these are not yet included.

(TC#500.3OREDIO)

EQUALS. *Assessment Alternatives in Mathematics*, 1989. Available from: University of California, Lawrence Hall of Science, Berkeley, CA 94720, 415-642-1823.

This document provides an overview of some possible assessment methods in mathematics that cover both process and products. Specific examples are provided for writing in mathematics, mathematical investigations, open-ended questions, performance assessment, observations, interviews, and student self-assessment. Any of the student generated material could be self-selected for a portfolio of work. The document also includes a discussion of assessment issues and a list of probing questions teachers can use during instruction.

(TC#500.6ASSALI)

Fraser, Barry, John Malone, and Jillian Neale. *Assessing and Improving the Psychosocial Environment of Mathematics Classrooms*. Located in: Journal for Research in Mathematics Education, 20, 1989, pp. 191-201.

This article describes the development of a short form of the *My Class Inventory* to be used in sixth grade math classes to measure the psychosocial characteristics of the classroom learning environment, i.e., social interactions.

(TC#500.3ASSIMP)

Glaser, Robert. *Expert Knowledge and Processes of Thinking.* Located in: Diane Halpern (Ed.), Enhancing Thinking Skills in the Sciences and Mathematics, 1992. Available from: Lawrence Erlbaum Associates, Publisher, 365 Broadway, Hillsdale, NJ 07642.

In this article the author describes research on expert performance. Although not directly about assessment, expert performance can be used to help understand and define the target we have for students, which is the first step toward designing assessment. For example, expert performance can be used to develop criteria for evaluating performance tasks.

The author points out that although expertise is very subject-specific, generalizations can be made about its nature across subjects: experts perceive large, meaningful patterns, have skillful self-regulatory processes, etc.

A critical point made by the author is that, "Practice, as it comes about in the usual course of training, is not necessarily very efficient. On the basis of our knowledge of the specific aspects of competence and expertise, we are not able to find ways to compress or shortcut experience.... This is one goal for performance assessment; we help students understand current conceptions of the relevant dimensions of a task so that they don't have to rediscover this themselves."

(TC#050.6EXPKNP)

Grobe, R.P., K. Cline, and J. Rybolt. *Curriculum Based Assessment For Math: A Summary of 1990 Field-Test Results*, 1990. Available from: Mt. Diablo Unified School District, 1936 Carlotta Dr., Concord, CA 94519.

The pilot project in Mt. Diablo school district entailed scoring open-ended math problems holistically for grades 3, 5 and 8. The holistic scale (0-4) defines an exemplary response as: systematic or elegant, organized recording system, complete and accurate, and clear and thorough explanation. One problem along with sample student responses is presented for each grade level. A rationale for using open-ended problems is also provided.

(TC#500.3MIDIAC)

Kansas State Board of Education. *Kansas Mathematics Standards and 1991 Kansas Statewide Pilot Assessment Results*, 1991. Available from: Kansas State Board of Education, Kansas State Education Building, 120 SE 10th Ave., Topeka, KS 66612.

This document includes an overview of the 1991 Kansas pilot math assessment and a description of results. The pilot included both multiple-choice and open-ended problems. The performance assessment portion was scored using a four-trait analytic model focusing on problem-solving processes (understanding the question, planning, implementing the strategies selected, and verifying the results). Each trait is rated on a six-point scale. Scoring guides and problems are included. Detailed instructions and sample student work are not included in this document. Some data are reported.

(TC#500.3KASMAS)

Knight, Pam. ***How I Use Portfolios in Mathematics*****, 1992. Located in: Educational Leadership, 49, pp. 71-72. Available from: Twin Peaks Middle School, Poway Unified School District, 14012 Valley Springs Road, Poway, CA 92064.**

The author describes her first year experimentation with portfolios in her algebra classes. She had her students keep all their work for a period of time and then sort through it to pick entries that would best show their effort and learning in algebra and the activities that had been the most meaningful. There is some help with what she did to get started and discussion of the positive effects on students. There is some mention of performance criteria, but no elaboration.

(TC#530.3HOWIUS)

Kulm, G. (Ed.) ***Assessing Higher Order Thinking in Mathematics*****, 1990. Available from: American Association for the Advancement of Science, 1333 H Street NW, Washington, D.C. 20005.**

This book contains a series of articles that address various topics in mathematics assessment. The articles address three broad topics:

1. The rationale for assessing mathematics problem solving and the need to have assessment devices that reflect this emphasis.

2. Issues that come up when trying to assess higher-order thinking skills in mathematics.

3. General discussions of what to assess and how to assess it.

There are a few examples of actual assessment techniques. The most relevant articles are included on this bibliography as separate entries.

(TC#500.6ASSHIO)

Larter, S. ***Benchmarks: The Development of a New Approach To Student Evaluation*****, 1991. Available from: Toronto Board of Education, 155 College Street, Toronto, Ontario, Canada M5T 1P6.**

Benchmarks are student performance assessment tasks tied to Provincial educational goals. Each Benchmark lists the goals to be addressed, the task, and the holistic scale used to judge performance. Students are also rated on perseverance, confidence, willingness, and prior knowledge, depending on the Benchmark. There are 129 Benchmarks developed in language and mathematics for grades 3, 6, and 8.

The percent of students in the sample tested at each score point (e.g., 1-5) are given for comparison purposes, as are other statistics (such as norms), when appropriate. Anchor performances (e.g., what a "3" performance looks like) are available either on video or in hard copy.

This report describes the philosophy behind the Benchmarks and how they were developed. Some sample Benchmarks (without anchor performances) are provided in the appendices.

(TC#100.6BENCHM)

Lash, Andrea. ***An Assessment of Mathematical Problem-Solving Skills*****, 1985. Available from: Far West Laboratory, 730 Harrison St., San Francisco, CA 94107, 415-565-3000.**

This monograph describes a study which examined seventh graders' skill in one aspect of mathematical problem solving--problem analysis. Problem analysis includes identifying information necessary to solve a problem, separating relevant from irrelevant information, identifying intermediate steps, and representing the information in a problem with a table or diagram.

The monograph describes possible assessment procedures for problem analysis (rating of open-ended solutions, purposeful multiple-choice), why they selected the latter procedure, and the types of problems that elicit problem analysis skills. The complete instrument is included.

(TC#510.3ANASSO)

Lehman, Michael. ***Assessing Assessment: Investigating a Mathematics Performance Assessment*****, 1992. Available from: The National Center for Research on Teacher Learning, 116 Erickson Hall, Michigan State University, East Lansing, MI 48824-1034.**

This monograph, by a high school math teacher, describes his attempt to develop a better method of assessing algebra problem solving, concepts and skills than traditional paper and pencil tests. The assessment technique involved giving students problems to solve as a group, and then having them explain their results in front of a panel of judges. Three examples of problems are provided, as is a brief description of the scoring criteria (making sense of the problem, and problem-solving strategies), accuracy of results, interpreting results, ability to communicate results, and an explanation of what they did. However, these criteria are not elaborated on, and, although samples of student explanations are provided, these are used to describe the understandings the teacher reached about his students, not to anchor the performance criteria.

The author also provides a brief summary of the strategies he uses to help students develop greater depth in their understanding of algebraic principals and their interrelationships--small group cooperative learning, requiring justifications of approaches, etc.

(TC#530.3ASSASI)

Lesh, R. ***Computer-Based Assessment of Higher Order Understandings and Processes in Elementary Mathematics*****, 1990. Located in: G. Kulm (Ed.),** **Assessing Higher Order Thinking in Mathematics****. Available from: American Association for the Advancement of Science, 1333 H Street NW, Washington, D.C. 20005.**

This article is as much about how meaningful learning occurs and the nature of the structure of knowledge in mathematics, as it is about use of computers in math instruction and assessment. The basic premise is that computer-based tests should not simply be pencil-and-paper tests delivered on-line. They should be part of an integrated instruction and assessment system that supports both learning facts and developing the meaningful internal structuring of these facts to form a coherent knowledge system.

The article discusses three things: (1) principles underlying a modeling perspective of learning and assessment (ideas such as: learning and problem-solving situations are

interpreted by the learner by mapping them to internal models; and, several alternative "correct" models may be available to interpret a given situation); (2) five objectives that should be emphasized in K-12 math (such as going beyond isolated bits of knowledge to construct well-organized systems of knowledge, and think about thinking); and (3) specific types of assessment items that can be used to measure these deeper and broader understandings (such as conceptual networks and interactive word problems).

Many sample problems are provided.

(TC#500.6COMBAA)

Lester, F.K. *An Assessment Model for Mathematical Problem Solving*, 1988. Located in: Teaching Thinking and Problem Solving, 10, 1988, pp. 4-7. Available from: Lawrence Erlbaum Associates, Inc., Journal Subscription Department, 365 Broadway, Hillsdale, NJ 07642.

This article presents a model for assessing both the problem solving performance of students and assessing the task demands of the problem to be solved. The dimensions of problem solving (which could be used as a scoring rubric(TC#500.3ANASSM)) are: understanding/formulating the question in a problem; understanding the conditions and variables in the problem; selecting the data needed to solve the problem; formulating subgoals and selecting appropriate solution strategies to pursue; implementing the solution strategy and attaining subgoals; providing an answer in terms of the data in the problem; and evaluating the reasonableness of an answer. The article describes these in some detail.

The problem features that can affect a student's success in solving a problem are: the type of problem; the strategies needed to solve it; the mathematical content/types of numbers used; and the sources from which data need to be obtained to solve the problem.

(TC#500.3ANASSM)

Lester, F.K., and D. Lambdin-Kroll. *Assessing Student Growth in Mathematical Problem Solving*, 1990. Located in: G. Kulm (Ed.), Assessing Higher-Order Thinking in Mathematics. Available from: American Association for the Advancement of Science, 1333 H Street NW, Washington, D.C. 20005.

The authors present a model of factors that influence problem-solving performance, and discuss several problem-solving assessment techniques.

A good assessment program in math should collect information about the following: affect (attitudes, preferences, and beliefs), and cognitive processes/ability to get the right answer (both whether they get the right answer, and the strategies used). The program should also systematically define and cover the features of tasks (problem type, math content, required strategies, etc.) since these affect performance and should be reflected in instruction.

In order to gather information on these three categories of factors, the authors briefly review: observations, interviews, student self-reports, and holistic and analytic scoring of performances. They recommend against multiple-choice questions.

This paper is a general theoretical discussion; no actual tasks, problems or scoring guidelines are provided.

(TC#500.6ASSSTG)

Long, Donna. *Mathematics Proficiency Guide*, **1991. Available from: Indiana Department of Education, Room 229, State House, Indianapolis, IN 46204, 317-232-9155.**

Although not strictly about assessment, this document has a nice description of mathematics proficiencies at various grade levels tied to specific instructional tasks. Proficiencies include: problem solving strategies, reasoning, communication, developing cognitive structures, applying math across the curriculum, and various knowledges (e.g. decimal places, measurement, and geometry).

(TC#500.5MATPRG)

Marshall, S.P. *Assessing Knowledge Structures in Mathematics: A Cognitive Science Perspective*, **1990. Located in: S. Legg & J. Algina (Eds.), Cognitive Assessment of Language and Mathematics Outcomes. Available from: Ablex, 355 Chestnut St., Norwood, NJ 07648.**

This article discusses the implications of recent advances in cognitive science for mathematics assessment. The goal in using this research to develop assessment techniques is to determine the extent to which students have acquired specific cognitive skills rather than merely whether they can correctly solve particular problems.

Cognitive theory holds that people solve problems by using three knowledge structures--declarative (facts), procedural (algorithms and production rules), and schema (frames that relate facts and production rules). To solve a problem, a person must first find the right schema, must then correctly implement a set of production rules, and must have stored correctly the facts and knowledge required to carry out the necessary algorithms specified by the production rules. Errors can occur in any of these three areas.

Researchers are currently engaged in specifying these knowledge structures in such detail that they can develop computer simulations that can, first, solve problems, and second, reproduce student errors by leaving out or altering various parts of the necessary structures. In this way, errors in student responses can be tracked back to the erroneous structure used. The author specifically mentions work in the area of simple arithmetic operations, geometry, and word problems.

Additionally, the author discusses two other ways of assessing these things in students--reaction time (to assess how automatic a function is); and multiple-choice problems (e.g., "which of the following problems can be solved in the same way as the one stated above?" to get at schema knowledge). Some time is spent with multiple-choice problems to explore various types of problems and the technical issues that arise with them.

It should be pointed out that all these procedures are experimental; none have progressed to the point where there is a final product that can be ordered and installed.

(TC#500.6ASSKNS)

Marshall, S.P. ***The Assessment of Schema Knowledge for Arithmetic Story Problems: A Cognitive Science Perspective*****, 1990. Located in: G. Kulm (Ed.), Assessing Higher Order Thinking in Mathematics. Available from: American Association for the Advancement of Science, 1333 H Street NW, Washington, D.C. 20005.**

The *Story Problem Solver* (SPS) was created to test a theory of memory architecture called schemata. Under such theories, human memory consists of networks of related pieces of information. Each network is a schema, a collection of well-connected facts, features, algorithms, skills, or strategies. SPS was developed to support instruction in story problems in which students were explicitly taught five problem-solving schemas and how to recognize which schema is represented by a story problem. The computerized problems have students pick out the schema or general solution strategy that fits the story problem, decide which information in the story problem fits into the various frames of the schema, identify the steps needed to solve a problem, and decide whether the necessary information is given in the problem.

(TC#500.3ASSOFS)

Math Learning Center. ***Recommendations for Assessment, Visual Mathematics*****, 1989. (Full reference not available.)**

This document is part of a longer monograph. Unfortunately, the longer source was not noted in the version we obtained. The excerpt briefly discusses using writing activities, checklists, quizzes, interviews, and self-evaluation to assess mathematics. The appendices contain a list of writing activities, journal exercises and starters, a checklist covering important dispositions, interview suggestions, and self-evaluation activities.

(TC#500.3RECFOA)

McTighe, Jay. ***Maryland School Performance Assessment System*****, 1991. Available from: Maryland State Department of Education, 200 West Baltimore St., Baltimore, MD 21201, 301-333-2390.**

This document includes Maryland's:

1. Philosophy for developing performance assessments
2. Statements of targets in reading, language arts and math
3. General guidelines for developing performance tasks
4. Sample performance assessment situations and scoring guides (with samples of student work) for grades 3, 5, and 8

From this package it appears that Maryland's approach is to present a problem situation with several different subproblems. Each of the subproblems focuses on a different objective: computation, problem solving, reasoning, communication, etc. Not all of the objectives are represented in the various problem situations. From this document it is difficult to judge the comparability of scoring guides across grades and problem situations (i.e., the extent to which the guides are tied to individual tasks). However, for

the problem situations given, sample student responses were provided to illustrate the score points.

(TC#500.3MDSCMA)

Meltzer, L.J. *Surveys of Problem-Solving & Educational Skills*, 1987. Available from: Educator's Publishing Service, Inc., 75 Moulton St., Cambridge, MA 02138.

Although this is an individual test published primarily for diagnosing learning disabilities for students aged 9-14, it has some interesting ideas that could be more generally applied. There are two parts to the test--a more-or-less standard individualized aptitude test, and a series of achievement subtests. The math subtest involves a fairly standard test of computation. However, the word problem subtest requires the teacher to score each problem on choice of correct operations, ability to complete the word problem, efficiency of mental computation, self-monitoring, self-correction, attention to operational signs, and attention to detail.

Another interesting part of this test is that after each subtest is administered, the teacher is guided through an analysis of the student's strategies in completing the task--efficiency of approaching tasks, flexibility in applying strategies, style of approaching tasks, attention to the task, and responsiveness during assessment. In the aptitude portion of the test, the teacher also assesses the student's ability to explain his/her own strategies.

A review in The Reading Teacher, November 1989, concluded that, since there is little evidence of validity presented by the author, the test should be used informally for classroom assessment. The reviewer also states: "The SPES, rather than attempting to measure underlying cognitive abilities, instead appear to emphasize underlying strategy awareness and use. This orientation appears to reflect the important recent developments in educational thinking emphasizing the child as a problem solver who uses intentionally selected strategies to improve understanding and learning." (p. 176)

(TC#010.3SUROFP)

Mumme, J. *Portfolio Assessment in Mathematics*, 1990. Available from: California Mathematics Project, University of California, 522 University Rd., Santa Barbara, CA 93106.

This booklet describes what mathematical portfolios are, what might go into such portfolios, how items should be selected, the role of student self-reflection, and what might be looked for in a portfolio. Lots of student samples are provided. Criteria for evaluating portfolios include: evidence of mathematical thinking, quality of activities and investigation, and variety of approaches and investigations.

(TC#500.6PORASI)

Nicholls, J.G., P. Cobb, E. Yackel, T. Wood, and G. Wheatley. *Students' Theories About Mathematics and Their Mathematical Knowledge: Multiple Dimensions of Assessment*, 1990. Located in: G. Kulm (Ed.), Assessing Higher-Order Thinking in Mathematics. Available from: American Association for the Advancement of Science, 1333 H Street NW, Washington, D.C. 20005.

This paper reports on a series of studies on student attitudes toward mathematics and their relationship to mathematical knowledge and understanding. Dimensions of attitudes toward math were: (1) how motivated students are to do math; (2) student

beliefs about what causes success in math; and (3) student views of the benefits of learning math. All items are included.

(TC#500.3STUTHA)

Pandy, Tej. *Power Items and the Alignment of Curriculum and Assessment*, 1990. Located in: G. Kulm (Ed.), Assessing Higher Order Thinking in Mathematics. Available from: American Association for the Advancement of Science, 1333 H Street NW, Washington, D.C. 20005.

The author presents a philosophy and approach for thinking about the development of a test of mathematics problem solving, and provides some examples of multiple-choice and short-answer "power" questions developed by the California Assessment Program.

The author maintains that typical content by process matrices used to specify the content of tests tend to result in tests that measure minuscule pieces of information that are fragmented and nonintegrated. The author prefers to have assessment tasks that are broader in focus and cut across several process/content areas, so that in order to get the right answer, students must use skills like organizing information, representing problems, and using strategies.

Multiple-choice or short-answer power questions have characteristics that include: they assess essential mathematical understandings and interconnectedness of mathematical ideas, rather than isolated facts and knowledge; they are not directly teachable, even though teaching for them will result in good instruction; good teachers looking at the questions would feel comfortable and agree that such questions are worthwhile teaching goals.

(TC#500.6POWITA)

Pandy, Tej. *A Sampler of Mathematics Assessment*, 1991. Available from: California Department of Education, P.O. Box 944272, Sacramento, CA 94244.

This sampler describes the types of assessment that the California Assessment Program (CAP) is proposing to support curricular reforms. Illustrated and discussed are open-ended problems, enhanced multiple-choice questions, investigations, and portfolios. These four types of activities are intended to measure mathematical understandings that students develop over a period of several years.

This monograph includes a definition of "mathematical power"--the ultimate goal of mathematics instruction, guidance in the characteristics of assessment tasks that will encourage and measure power, a few sample student responses to problems, and help with implementation of alternative assessment.

All performance-based techniques will use a six-point holistic scale. This scale is briefly described. The scale will be tailored for individual tasks.

(TC#500.3SAMMAA)

Psychological Corporation. ***Integrated Assessment System: Mathematical Performance Assessment*****, 1991. Available from: Psychological Corporation, 555 Academic Court, San Antonio, TX 78204, 800-228-0752.**

This is a series of 16 performance tasks designed for use in grades 2-8 (two per grade). These tasks include such things as figuring out an answer and explaining how the solution was reached, doing a series of solutions based on one scenario, generating a general principle and applying it to a new situation, etc. Tasks are cross-referenced to skills such as problem solving, communication, estimation, reasoning, and statistics. The examination set we received was a little sketchy on how all of this fits together.

Problem solutions are scored either holistically (6-point scale) or analytically (4 traits, 4-point scales) using the same rubrics across tasks. Scoring can be done either locally or by Psychological Corp. The examination set includes descriptions of the scales but no anchor performances. The anchor set also does not include technical information. Some suggestions are given for planning instruction based on results.

It appears that this information would be of most use in grades 3 and above, although the monograph itself does not specify grades.

(TC#500.3INTASM)

Psychological Corporation. ***GOALS: A Performance-Based Measure of Achievement*****, 1992. Available from: Psychological Corporation, 555 Academic Court, San Antonio, TX 78204, 800-228-0752.**

GOALS is a series of open-ended questions designed to supplement the SAT-8. There are tests for grades 1-11 in language arts/reading, mathematics, science, math, and social studies. Each test has 10 items. Items are scored using a four-point holistic system (not tied to individual tasks) that emphasizes both process and product.

The preview booklet used for this review did not mention technical information, but did include some sample items.

(TC#510.3GOALS)

Randall, C., F. Lester, and P. O'Daffer. ***How to Evaluate Progress in Problem Solving*****, 1987. Available from: National Council of Teachers of Mathematics, 1906 Association Drive, Reston, VA 22091.**

This monograph attempts to assist educators with the challenge of developing new techniques for evaluating the effectiveness of instruction in problem solving by clarifying the goals of problem-solving instruction, and illustrating how various evaluation techniques can be used in practice. Goals include: select and use problem-solving strategies, develop helpful attitudes and beliefs, use related knowledge, monitor and evaluate thinking while solving problems, solve problems in cooperative learning situations, and find correct answers.

Evaluation strategies include: informal observation/questioning and recording results using anecdotal records or a checklist (two are provided); interviews (a sample interview plan is provided); student written or oral self-report of what happening during a problem-solving experience (a list of stimulus questions is given, as is a checklist of strategies); attitude inventories (two are given); rating scales (three-trait analytic, and focused holistic scales are given); and multiple-choice and completion (sample items are given to

assess various problem solving abilities; many of these parallel question types mentioned by Marshall, above, to assess procedural and schematic knowledge).

Many sample problems are provided.

(TC#500.6HOWTOE)

Riverside Publishing Company. *The Riverside Curriculum Assessment System: Performance Test Exercises*, 1991. Available from: Riverside Publishing Company, 8420 Bryn Mawr Ave., Chicago, IL 60631.

The Curriculum Assessment System is a customized test development program offered by Riverside. The Performance Test Exercise part of the System is a recently developed portion of this program that requires students to generate answers rather than choose answers.

Tasks center upon a given scenario, and involve from three to ten problems based on this scenario. Student responses to each problem are awarded point values depending on the presence of certain features in the response. Thus, criteria are tied to specific tasks. All scoring is done locally. No technical information is provided, so there is no way to judge whether the list of skills claimed to be required to do each task really is required.

(TC#060.3RIVCUA)

Romberg, T.A. *The Domain Knowledge Strategy for Mathematical Assessment*, 1987. Available from: National Center for Research in Mathematical Sciences Education, School of Education, 1025 W. Johnson St., Madison, WI 53706, 608-263-4200.

This document provides a brief overview of the "Domain Knowledge" strategy used by the National Center for Research in Mathematical Sciences Education to assess math knowledge of students. This approach is contrasted to the typically used "Content by Behavior Matrix" approach in which content topics are crossed with behavior (usually some form of Bloom's taxonomy). The author maintains that this approach is outdated; the behaviors dimension fails to reflect contemporary notions of how information is processed and the content dimension is an inadequate way to describe what is meant by "knowing mathematics."

The "Domain Knowledge" approach involves making a "map" or network of a concept domain. This reflects a more integrated and coherent picture about knowledge. These maps can be used to generate tasks, assessment criteria, and formats that get at both correctness of responses and the strategies used to arrive at the answer.

(TC#500.6DOMKNS)

Romberg, Thomas, Ann Zarinnia, and Steven Williams. *The Influence of Mandated Testing on Mathematics Instruction: Grade 8 Teachers' Perceptions*, 1989. Available from: National Center for Research in Mathematical Sciences Education, School of Education, 1025 W. Johnson St., Madison, WI 53706, 608-263-4200.

This monograph reports on the first of a sequence of studies on mandated testing in mathematics. This study was a large-scale questionnaire survey to find out from Grade 8 teachers how influential mandated testing was on their teaching of mathematics. The results of the study showed that nearly 70 percent of the teachers reported that their students take a mandated test. Secondly, because teachers know the form and character

of the tests their students take, most teachers make changes in their teaching to reflect this knowledge. Third, the kind of changes teachers make are in contrast to the recommendations made by the NCTM standards. Specific examples are given.

Although this paper does not describe an alternative assessment device, it does provide reasons for seeking alternative ways of assessment math.

(TC#500.6INFMAT)

Romberg, Thomas, Linda Wilson, and 'Mamphono Khaketla. *An Examination of Six Standard Mathematics Tests For Grade Eight*, 1989. Available from: National Center for Research in Mathematical Sciences Education, School of Education, 1025 W. Johnson St., Madison, WI 53706, 608-263-4200.

This study is a follow-up to the survey of teachers described above. The authors analyzed the six tests most commonly cited by the eighth grade teachers in that study as being used with their students. The authors conclude that the six standardized tests are not appropriate instruments for assessing the content, process, and levels of thinking called for in the NCTM Standards.

(TC#500.6EXASIS)

Romberg, Thomas. *Evaluation: A Coat of Many Colors*, 1988. Available from: National Center for Research in Mathematical Sciences Education, University of Wisconsin, School of Education, 1025 W. Johnson St., Madison, WI 53706, 608-263-4200.

This paper describes the impact of assessment information on decision making and describes the ways in which assessment must change if it is to have a positive impact on such decisions.

(TC#500.6EVACOM)

Romberg, Thomas. *Assessing Mathematics Competence and Achievement*, 1989. Available from: National Center for Research in Mathematical Sciences Education, University of Wisconsin, School of Education, 1025 W. Johnson St., Madison, WI 53706, 608-263-4200.

This paper describes the author's view of what it means to be literate mathematically. It then describes the instructional and assessment implications of this goal. The author believes that we need to assess not only mathematical knowledge but also the structure of the knowledge.

(TC#500.5ASSMAC)

Schoenfeld, A.H. *Teaching Mathematical Thinking and Problem Solving*, 1989. Located in: L.B. Resnick & L.E. Klopfer (Eds), Toward The Thinking Curriculum: Current Cognitive Research. Available from: Association for Supervision and Curriculum Development, 1250 N. Pitt St., Alexandria, VA 22314-1403, 703-549-9110.

Although this article is more about defining what mathematical problem solving is than about assessment, it presents an interesting visual way to represent how students spend their time when solving a problem; it also compares such a plot for good problem solvers to a plot for an inefficient problem solver.

Essentially, the procedure involves tracking the sequence in which students use different steps in the problem-solving process (reading the problem, analyzing the problem, exploring a solution strategy, planning, implementing a strategy, and verifying the results) and the amount of time spent on each. Good problem solvers spend a lot of time analyzing and planning, with many self-checks on "how it is going." Poor problem solvers tend to fixate on a possible line of attack and pursue it relentlessly even when it is clearly not going well. Additionally, there are very few stops to self-check on how it is going.

(TC#500.5STOWTET)

Silver, Edward and Jeremy Kilpatrick. *Testing Mathematical Problem Solving.* Located in: R. Charles and E. Silver (Eds.), The Teaching and Assessing of Mathematical Problem Solving, 1988. Available from: National Council of Teachers of Mathematics, Inc., 1906 Association Drive, Reston, VA 22091.

This paper discusses two topics: how assessment can inform instructional decision making and how it communicates what we value. The authors propose that the National Assessment of Educational Progress and many other math tests do not provide the type of information needed for the improvement of mathematics instruction. The information useful for improvement of instruction would be types of errors kids make, how automatic mathematical processes are, and the cognitive structures and abilities associated with expertise in the domain being tests.

(TC#500.6TESMAP)

Stenmark, Jean. *Mathematics Assessment: Myths, Models, Good Questions, and Practical Suggestions*, 1991. Available from: National Council of Teachers of Mathematics, 1906 Association Drive, Reston, VA 22091.

This monograph was designed for teachers in the elementary grades. It is a collection of examples of assessment techniques that focus on student thinking. Topics include the rationale for new ways of assessing mathematics, the necessity of integrating assessment and instruction, designing performance assessments (most emphasis is on designing the task, although sample holistic and analytical trait scoring systems are shown), what to look for during classroom observations and interactions (including questions to ask to get at various types of thinking), portfolios (including types of items to include and the types of information they can demonstrate about students, and criteria for evaluation), student self-assessment, and hints to make it work in the classroom.

(TC#500.3MATASM)

Surber, J.R. *Mapping as a Testing and Diagnostic Device*, 1984. Located in: C.D. Holley & D.F. Dansereau (Eds.), Spatial Learning Strategies--Techniques, Applications, and Related Issues. Available from: Academic Press, 6277 Sea Harbor Dr., Orlando, FL 32887, 800-321-5068.

The book is a general discussion of the advantages of, and procedures for, integrating the production of cognitive networks into instruction. The premise is that knowledge of facts, rules, algorithms, etc. is only part of what students need to know. They also need to know how these facts fit together to form a body of knowledge. Without knowledge of the interrelationships, students are not likely to remember the facts or be able to use them correctly when they are remembered.

The Surber paper discusses a particular type of cognitive networking scheme--mapping--and its use in assessment of knowledge structures. The basic procedure consists of taking a completed map for the topic to be tested, and deleting portions in various ways. Students then complete the map given various types of cues.

(TC#000.6MAPASA)

Vermont Mathematics Portfolio Project. *Resource Book*, 1991. Available from: Vermont Department of Education, 120 State Street, Montpelier, VT 05602, 802-828-3135.

This document includes sample performance tasks taken from portfolio entries submitted by teachers as part of Vermont's 1991 math portfolio pilot project, a resource bibliography, and a list of suggested readings. The purpose is to provide colleagues with tasks that have worked well with students to promote problem solving. This is meant as a companion document to the Teacher's Guide (TC#500.3TEAGUI).

(TC#500.3RESBOO)

Vermont Mathematics Portfolio Project. *Teacher's Guide*, 1991. Available from: Vermont Department of Education, 120 State Street, Montpelier, VT 05602, 802-828-3135.

This document presents Vermont's current view of what should go into a mathematics portfolio, provides detailed information about the scoring criteria for portfolio entries and the portfolio as a whole, discusses how to develop tasks that will invite student problem solving, and provides help with how to manage the portfolios. This is a companion piece to the Resource Book (TC#500.6RESBOO).

(TC#500.3TEAGUI)

Vermont Mathematics Portfolio Project. *Grade Eight Benchmarks*, 1991. Available from: Vermont Department of Education, 120 State Street, Montpelier, VT 05602, 802-828-3135.

This document provides lots of samples of grade eight student work that illustrate different scores for each of the seven analytical traits used in the Vermont Mathematics Portfolio Project. Samples were taken from the 1991 portfolio pilot.

(TC#500.3GRAEIB)

Vermont Mathematics Portfolio Project. *Grade Four Benchmarks*, 1991. Available from: Vermont Department of Education, 120 State Street, Montpelier, VT 05602, 802-828-3135.

This documents provides lots of samples of grade four student work that illustrate different scores for each of the seven analytical traits used in the Vermont Mathematics Portfolio Project. Samples were taken from the 1991 portfolio pilot.

(TC#500.3GRAFOB)

Vermont Mathematics Portfolio Project. ***Looking Beyond 'The Answer'--The Report of Vermont's Mathematics Portfolio Assessment Program*****, 1991. Available from: Vermont Department of Education, 120 State Street, Montpelier, VT 05602, 802-828-3135.**

This report describes the results of the pilot year of the Vermont's grade 4 and 8 mathematics portfolio system used for large-scale assessment. The report contains information on the rationale for the portfolio approach, a description of what students were to include, a description of the criteria used to evaluate the portfolios (with sample student performances to illustrate the scoring scale), the scoring and training process, results, and what was learned about large-scale assessment using portfolios.

(TC#500.3REPOFV)

Webb, N. ***Alternative Strategies for Measuring Higher Order Skills in Mathematics: The Role of Symbol Systems*****, 1991. Available from: CRESST, University of California, Los Angeles, 145 Moore Hall, Los Angeles, CA 90024. 213-825-4711.**

This document presents an overview of a study that is currently taking place at CRESST in which students are asked to represent problems in various equivalent ways (graphs, tables, equations, word problems, and diagrams). The premise is that if a student really understands a problem, he or she should be able to solve the problem presented in any format, and translate from one format to another. Examples are provided of problems represented in different ways.

(TC#500.6ALTSTF)

Wells, B. G. ***Journal Writing in the Mathematics Classroom*****, 1990. Located in: Communicator, 15, 1, pp. 30-31. Available from: California Mathematics Council, Ruth Hadley, 1414 South Wallis, Santa Maria, CA 93454, 805-925-0774.**

This brief article describes one method that a teacher uses to elicit thinking on the part of high school math students. The teacher puts a short phrase on the board at the beginning of each class period and students write what they know about that phrase as the teacher takes attendance. Sample "prompts" and student responses are included. Although no criteria for evaluating responses is included, this article is added here because it represents an attempt to do writing in math, and because some of the prompts are designed to elicit metacognition, e.g., "What three problems on the final should have been eliminated and why?" or "What mathematical fact, concept, skill or insight that you learned in this class this year are you most likely to remember and why?"

(TC#500.6JOUWRI)

Whetton, C., G. Ruddock, S. Hopkins, et al. ***Standard Assessment Tasks for Key Stage 1*****, 1991. Available from: HMSO Publications Centre, P.O. Box 276, London, SW8 5DT, England.**

In spring 1991, all seven-year-olds in England and Wales (N=600,000) where to have been tested using a set of performance assessments tied to a new National Curriculum. Areas tested included reading, writing, spelling, handwriting, math, and science. The assessment consisted of a series of tasks given to students. For each task, students were assessed on several "statements of attainment (SoA)" (goals in the curriculum). In math, thirty-eight SoAs were covered in 19 tasks. SoAs included those that are fairly traditional (e.g., "use addition and subtraction facts up to 10") but also included some

self-reflection and problem solving (e.g, "talk about own work and ask questions," "make predictions based on experience," "explore and use the patterns in addition and subtraction facts to 10").

(TC#070.3STAAST)